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THE REPUTATION OF BIRCH FOR SOIL IMPROVEMENT

A Literature Review

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INTRODUCTION

In an article in the Quarterly Journal of Forestry, A. M. Petch (1965) draws attention to the lack of knowledge on the use of fertilizers in forestry and suggests that the current belief in the soil-improving qualities of hardwoods is the main contributory factor.

In that article Petch states, in his opening paragraph, "If looked at objectively, it would seem that the soil improvement qualities attributed to such leaf trees as beech, birch and rowan in coniferous stands are over-stressed by many silviculturists." Although he subsequently offers some supporting evidence against beech, he says nothing which condemns the other two species. However, it is probably true to say that birch is more often cited as a soil improver than either beech or rowan, and the writer, as a birch breeder, has been faced many times with the problem of finding an acceptable answer to questions on this particular attribute of birch.

In order to find out how this reputation for improvement has been gained, and to separate genuine observation from hearsay, it has been necessary to study in some depth the appropriate forestry history.

An examination of the relevant literature shows that the casting of birch in this role is not of recent origin, but dates back at least to the eighteenth century. Since that time, its reputation has grown through the comments, observations and detailed studies of many workers in various European countries. It appears to have arisen in two ways: indirectly by observation of the behaviour and effect of birch—either as a nurse crop or in true mixture, natural and artificial—on other species; or directly from studies of the effect of birch on the forest soil.

THE HISTORY OF BIRCH AS A NURSE AND PIONEER SPECIES

As a starting point and subsequent guide, the writer has drawn heavily on an excellent paper by Fiedler (1962), which deals with the evolution of the concept of nurse species, particularly birch. This indicates that the origins of the reputation of birch in improving forest conditions are probably German.

The first references take us back to the early decades of the nineteenth century, to works by Cotta and Pfeil. In 1817, Cotta described the role of birch and pine in providing shade for the regeneration of beech. In 1845, we learn from the same author that the species, intended to provide protection against heat and cold, must be taller than the protected species. The species he recommended were birch, Scots pine and red-berried elder (*Sambucus racemosa*).

Pfeil (1829) strongly urged the use of mixtures of pine and birch, because they would not only produce higher and more valuable yields from thinnings, but the growth of the pines would be improved and resistance to needle cast, insect attack and snow damage would be increased. He turned his attention later to mixtures of spruce and birch, when, drawing on the experience of a forester in the Harz mountains, Pfeil (1841) pointed out that dangers from snow break in spruce could be countered by the brushing action of the birch branches. In a third paper (Pfeil, 1860), which added support to Cotta's recommendation, he proposed that the birches should be planted at wide spacing or in widely-spaced rows which should later be interplanted with beech or other species requiring protection.

In the early 'fifties of the last century, the idea of using pioneer species received considerable attention in Switzerland—during a period of policy change from low to high forest systems—particularly in a paper by Kasthoffer (1850). This was followed by a report from Gehret (1851) of a meeting and excursion of the Schweizerischer Forstverein, when terms, new to forestry, such as pioneer forest practice, pioneer forest system and pioneer forest trees were discussed; birch with pine, larch and *Robinia* were recommended as particularly suitable species.

Later, however, steps were taken by forest administrations in general to eliminate birch, especially where it occurred naturally in managed coniferous stands, and the term "weed species" began to appear in forest literature, *e.g.* Brown and Nisbet (1894). But several foresters, who considered birch to be a useful timber species, welcomed the idea of mixtures involving birch nurses; an anonymous writer in 1852 stated that its good protective effects cannot be stressed sufficiently.

During the second half of the nineteenth century, some controversy centred on pine-birch mixtures. Brecher (1875) wrote that, during the great pine-shoot moth attacks of 1861-70 in the Mark Brandenburg, it was striking that pine stands mixed with a few hardwoods, such as birch, oak and aspen, were protected against damage. At the same time he cited another authority, Burghardt, who was of the opinion that, although birch gave protection, it had to be used with other species as it lacked the ability to improve the soil. This opinion is also held to-day by many foresters with knowledge of the same region (pers. comm.).

Von Fischbach (1892) found himself in agreement with Burghardt's view and opposed to those of the earlier writer, Pfeil. He stated: "I was able to make fairly detailed observations of the behaviour of pine and birch in mixed stands at different phases in the North German low plains, of varying ages and various degrees of mixture, in the provinces Posen, Brandenburg, Pommerania and Silesia. In no case did I notice a satisfactory coexistence."

In Sweden, however, Holmerz and Örtenblad (1886) observed that birch speeded up the growth of pine and eventually—being short-lived—dropped out of the stand. At the same time, they pointed out that birch prevented pine from developing strong side branches. Godbersen (1904) perceived the opposite effect on branching and wrote—again on German experience—that birch caused the pine to develop branches and bad form.

After the First World War, a number of papers appeared in Germany dealing with nurse and pioneer crops in which birch figures very often. Rebel (1924) describes the forest conditions in some parts of Bavaria after the nun moth disasters of 1920, and the role of pioneer crops in restocking clear-felled areas; Buhler (1922) and Mayr (1925) outline the function of nurse species and their management. Their protective effects are again stressed by Rubner (1921) and Straudacher (1924).

Apart from comparative studies of yield, the first scientific study of conditions in a nurse crop would appear to be that of Amann (1930), who made temperature measurements inside and outside a birch shelterwood. He observed that the average minimum temperature inside, at a height of 25 cm above ground level, was 4·5°C above the surrounding area. Later this field of study was further explored by Göhre (1954), Linder (1956) and Baumgartner (1956).

Göhre studied the daily course of temperature both above and below the soil, as well as wind, evaporation and humidity, within and without a pine crop with birch nurses, over a period of six months. He reached the conclusion that the forest climate was only moderately improved by the nurse crop. The study was carried out in North-east Germany and his findings echo the earlier observations of Von Fischbach; the birch nurses competed with the pines for water, soil nutrients and light, and created conditions favouring needle cast. He stressed, however, that his observations did not apply to the growing of the other species on other soil types, but particularly to pines on diluvial soils accompanied by low rainfall.

The favourable effects on growth of a birch nurse crop, sown at the same time as spruce, silver fir and oak, in contrast with pure spruce, which were observed by Linder (1956), formed the subject of an investigation by Baumgartner (1956). He recorded such factors as soil temperature, transpiration over the growing period, precipitation and dew. However, he concluded that the small differences in these factors between the two crops did not account for the differences in growth, and suggested greater air stability within the nurse crop, resulting in increased CO_2 concentrations and greater soil activity.

Before the onset of the Second World War, Isachenko (1939) in Russia published the results of experimental plantations of birch-pine-spruce and birch-spruce mixtures after 30-40 years of growth. Planting in alternate rows had led to considerable damage to the pine and the spruce. In the three-species mixture survival was highest in the spruce. He recommended various alternate planting schemes, depending on the soil conditions, for future plantations.

During the war, Altmann (1940) noted the reduction in insect attacks in pine stands in the Nuremberg State Forest through the employment of mixtures of spruce and alder. Other hardwoods were also tried and birch proved to be as good as alder, but suffered from browsing by deer.

The end of hostilities produced, as in the decade following the First World War, several papers in Germany which urged the use of nurse crops in the task of post-war reafforestation; birch again was given a strong recommendation (Krutzsch 1948, Rohmeder 1947 and 1952, Weck 1944, 1948 and 1952). These authors were followed later by Korell (1958) and Wendt (1958) who discuss the silvicultural treatment of pioneer and nurse crops and species.

Further south in Switzerland, Leibundgut (1948 and 1953/54) also stressed the silvicultural advantages of protective species and was firmly convinced of their economic and biological value. In a later paper with Kreutzer (1958) it is pointed out, however, that the root competition, particularly in birch mixtures, should not be underestimated. In a series of experiments in mountain afforestation, involving spruce, pine and oak with birch, aspen and alder nurses, root competition was greatest in the birch mixtures.

The protective effects of birch are particularly highlighted in a study of the pattern of storm damage in three areas in Sweden. After a gale in January 1954, Werner and Årmann (1954) reported that in resistance to windthrow, birch was superior to pine and spruce; also, coniferous stands with an admixture of birch were more resistant than pure stands.

Evidence of the beneficial effects of birch in British woodlands is available from various sources. The improved growth of beech on a chalk downland site in Sussex is described by Brown (1955), and, based on experience, Stocks (1961) listed the management advantages of shelter on frost-tender species. Early Forestry Commission research experiments, planted in 1927 at Friston (ash-birch and beech-birch) and Thetford (various exotic conifers and beech with birch nurses) add strong support.

However its value on exposed sites over poor peat was described as very low by Zehetmayr (1954). In most experiments survival was poor; at Kielder, in one successful experiment (15, P 30) birch had grown faster than Sitka spruce, and eight years later had to be cut back. In addition it had produced no effect on the growth of the spruce.

It can be seen that, apart from the reservations of those German writers who observed the bad effects of birch in mixture with pine, particularly in North-east Germany, most of the evidence is favourable. Although only a few of the authorities cited specifically suggest soil improvement under birch crops or birch mixtures, the bulk of what they have written can only have contributed to enhancing its reputation in this respect.

BIRCH AS A SOIL IMPROVER

The reputation attached to birch as soil improving species is almost legendary. Nearly all general treatises on forestry touch on it, often as the important virtue of an otherwise unimportant hardwood or in a manner reminiscent of a "worthy cause" appeal.

It is interesting, therefore, to examine the written record, to see how this reputation has been acquired and in order to obtain some measure of the true value of birch in improving soil conditions.

The background of this particular attribute is again one of a gradual build-up, from the general observational remarks of early writers to the stronger conclusions, reached after more intensive study by recent workers.

Early references are scarce, but a remark by Gross (1925) would seem to indicate an eighteenth century origin. He comments: "At the end of the eighteenth century, in Tharandt in Germany something approaching a birch mania developed, which seemed a suitable means for restocking soils which had been degenerated by misuse of many kinds." However, although many nineteenth-century foresters wrote about the protective influences of birch on other crops, only a few went so far as to mention soil improvement.

Kasthoffer (1850) recognized the following advantages of a naturally regenerated pioneer stand: protection against climatic extremes, including snow breakage; low establishment costs; soil improvement through better humus conditions due to leaf fall.

In the twentieth century references become more numerous. Hess (1914) and Hesselmann (1926) support the view that a pine-birch mixture maintains better soil productivity through protective shade and nutritious manuring, this latter resulting from leaf fall and its quick decay. This opinion is maintained later by Nemec and Kvapil (1927), who go so far as to state that such mixed stands, i.e. birch and pine, are a stipulation for better nitrate development, though at that date this had not been proved by examination.

In a general description of birch in Sweden, Tillander (1941) states that young birch is valuable as a soil improver, but with advancing age these properties decrease.

One year earlier, Tamm (1940) published his work on Northern coniferous forest soils; it contains strong indications of soil enrichment under birch. On page 187 of the English translation (1950) it is stated that, "To the credit side of burning may also be put the promotion of birch regeneration, by which, as after a fire, an improved condition of the humus can be achieved for a long time ahead." Later, on page 224, we read: "It is notorious that the first generation of spruce, planted on old leaf tree meadows in birch pastures or on beech forest soils, grows with striking rapidity. This seems to be true, even when it is a question of morainic soils of normal quality, which in the same districts, when they have not immediately previously been covered by leaf-tree forests, give rise to a spruce forest or mixed conifer forest of more ordinary growth."

Some of the earliest experimental evidence is to be found in a piece of research by Schneider (1940), in which birch is recommended in mixture with other hardwood species as a means of producing satisfactory humus conditions in the pine forests of North-west Germany.

Perhaps the strongest support for the soil improving qualities of birch is contained in the investigations of Dimbleby (1951, 1952a and b, 1953). His studies on the North-east Yorkshire moors reveal the striking effectiveness of birch in reversing the podsolisation process to one producing brown forest soil conditions. When contrasted with a 100-year old pine stand in which the soil conditions were virtually unchanged, the soil under various birch stands had been altered considerably. Mor accumulation had been halted and the original raw humus converted to an intimate mixture of mull and mineral soil. The soil fauna, had increased and was more characteristic of deciduous woodland conditions. Examination of the two root systems indicated that birch was better adapted for colonization after fire, and superior in penetrating and exploiting the subsoil; root sap analyses showed that the birch sap was richer in nutrients.

In Germany similar effects were noted on heathland soils under pine, birch and oak, by Burrichter (1954). Ovington (1953) observed less acidity under hardwoods, including birch, and more indications of leaching under conifers at two sites in Norfolk.

The value of birch in improving soil aeration is somewhat less striking. In studies on the porosity, moisture and aeration of moorland soils at Wykeham Low Moor, Rennie (1953) reports that birch, in contrast with Japanese larch, pines and Sitka spruce, appeared least able to improve aeration within the upper 50 cm of the forest soil.

Malcolm (1957) concluded after extensive study of soil degradation in natural pine stands in North-west Perthshire and East Argyll, that the function of secondary leaf-tree species, birch being the most important, was to prevent degradation and to check its progress once it had begun.

Also in the Scottish Highlands, McVean and Ratcliffe (1962) noted less marked podsolization under birch communities than under pine communities. Over siliceous parent material, however, they observed the failure of birch to convert mor to mull humus.

Gavrilov (1950) reported from Russia on comparative studies, made at two widely-separated experimental areas and on two different soil types (a medium podsol and a grey forest soil). Oak, birch and Scots pine stands were studied at both localities, together with a mixed European and Siberian larch stand at one locality and a Norway spruce stand at the other. Soil conditions, despite uniformity of soil type within each locality, were considerably richer in fauna and mineral salts and were less acidic under the two hardwoods, especially the oak, than under conifers. Soil analyses, made during the growing season in another Russian experimental forest area by Kovrigin (1952), strengthen Gavrilov's observations.

More recently, Maninskij (1965) discusses the results of studies made in 14 year old pine, pine-birch and birch plantations in the Moscow region. In the mixed stand the soil acidity was lower and the nutrient content higher than in the pure stands. Also, in contrast to pure stands, the weight of the aerial parts and roots was higher for birch and lower for pine.

INCREASED PRODUCTIVITY

In making a strong case for birch those papers which indicate that, by the use of birch-conifer mixtures, we can expect an increase in the total yield per unit area and in some instances, an increase in the yield of the main crop, must be of considerable impact.

One of several interesting examinations by Jäger (1843) was carried out at Erbach in Darmstadt, Germany. Comparisons in yield were made between a pure birch crop, a pure pine crop and a mixed pine-birch crop, all 54 years of age, of the same area and growing under similar forest conditions. Supported by tabulated data he claimed that the mixture yielded an increase of 11 per cent in volume in contrast to the volumes of the pure pine and pure birch considered together. In addition he remarked that the form and branch-free area of the pine stems were improved considerably.

In Finland, two extensive yield studies were made by Lappi-Seppäla (1930 and 1938) of natural pine, birch and mixed pine-birch stands. With data from numerous sample plots on three different site-types he demonstrates the superior productivity of the mixed stands. In certain types of mixture the yield of the pine was superior to that of a comparable pure stand. The characteristic behaviour of such mixtures appears to be that the birch develops rapidly in the early decades but later slows up considerably; the higher the proportion of birch, the smaller becomes the total volume production of the mixture. The most profitable proportions appeared to be 40 per cent birch and 60 per cent pine.

Koslowski (1960), after examining the data from 400 sample plots on an experimental site in North Russia which had been planted some twenty years earlier with birch-spruce and pure spruce, reached the following conclusions: Birch has a definite positive influence, the upper layers of the soil are richer in nitrogenous matter, phosphorus and potassium. This influence is reflected in the improved growth of spruce. Maintenance of the birch in the mixture is necessary for a certain period only, after 20 to 30 years the birch can be removed. In contrast with pure stands the increase in growth of the spruce is of the order of 10 to 15 per cent.

Koslowski's paper appears to be the most recent of its kind and would have carried more weight, had he published at least a summary of the data on growth comparisons.

In concluding, there can be little doubt that, apart from the objections of those foresters who noted its bad influence on the growth of pine in North-east Germany, the case for birch, both as a nurse and soil-improving species, is a good one. In order to sum up, it is perhaps fitting to cite the important advantages of nurse species, particularly birch, as described by Heger (1952) in the most extensive work on the subject, because they summarize and highlight the silvicultural benefits that are offered by the correct use of birch.

1. Protection; provision of a favourable forest climate and protection against extremes, as well as reduction of insect attacks.
2. Soil improvement through the decomposition of leaves and effective exclusion of weeds and grasses.
3. Increases in total volume production.

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